Fundamental Study on Structural and Surface Control on Single Crystalline Metal Oxide Nanowires

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出版情報：Kyushu University, 2021, 博士（工学）, 課程博士
バージョン：
権利関係：

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論 文 名　：Fundamental Study on Structural and Surface Control on Single Crystalline Metal Oxide Nanowires
（ 単結晶金属酸化物ナノワイヤの微細構造・表面構造制御に関する基礎的研究 ）

Title:

区　　分　：甲

Category　　Kou

論 文 内 容 の 要 旨

Thesis Summary

Metal oxide nanowires are promising building blocks for various applications due to their unique physical and chemical properties. Among various nanowire growth methods, a hydrothermal method is particularly promising because the process can be performed at relatively low temperatures (<100 oC). Although efforts have been made to investigate a synthesis and control of hydrothermal single crystalline metal oxide nanowires, there are still challenging and interesting issues as to the controllability of nanowire size distributions and the surface modification and functionalization.

Firstly, I demonstrate the effect strategy of excessive ammonia addition to significantly increase on the growth rate of ZnO nanowires. We found that the ammonia addition substantially narrows the width of “concentration window”. The narrowed “concentration window” and the resultant increased growth rate by the ammonia addition can be understood in terms of synchronized effects of both (1) a reduction of zinc hydroxide complex (precursor) concentration and (2) a fast rate limiting process of ligand exchange between different zinc complexes. The present knowledge of “concentration window” will accelerate further tailoring an anisotropic crystal growth of hydrothermal ZnO nanowires. Secondly, I demonstrated a facile, rational method to synthesize monodispersed sized zinc oxide (ZnO) nanowires from randomly sized seeds. Uniformly shaped nanowire tips constructed in ammonia-dominated alkaline conditions serve as a foundation for the subsequent formation of the monodisperse nanowires. By precisely controlling the sharp tip formation and the nucleation, our method substantially narrows the distribution of ZnO nanowire diameters. The proposed concept of sharp tip based monodisperse nanowires growth can be applied to the growth of diverse metal oxide nanowires and thus paves the way for bottom-up grown metal oxide nanowires-integrated nanodevices with a reliable performance. Finally, I demonstrated an emergence of a thermally robust molecular selectivity with one carbon resolution for aliphatic chains of aldehydes on molecularly templated single crystalline ZnO nanowire surfaces with amorphous TiOx shell layers grown by atomic layer deposition. Spectroscopic, spectrometric and microstructural measurements revealed that such molecular selectivity only emerged when controlling the number of atomic layer deposition cycles with anchoring spatially isolated target-aliphatic aldehyde molecules on the ZnO surface during shell layer formations. This present method to create thermally robust molecular selectivity on abundant oxide surfaces is shown to be simple and highly reproducible and holds promise for scalability and applicability to various molecules.